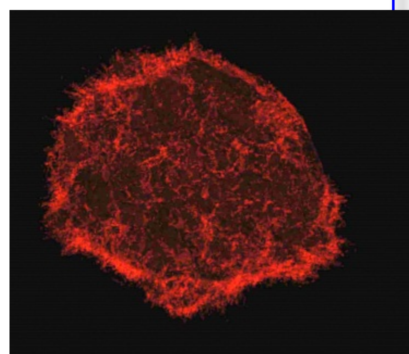
Nuclear Science Division Newsletter

In this issue: **February 2012**

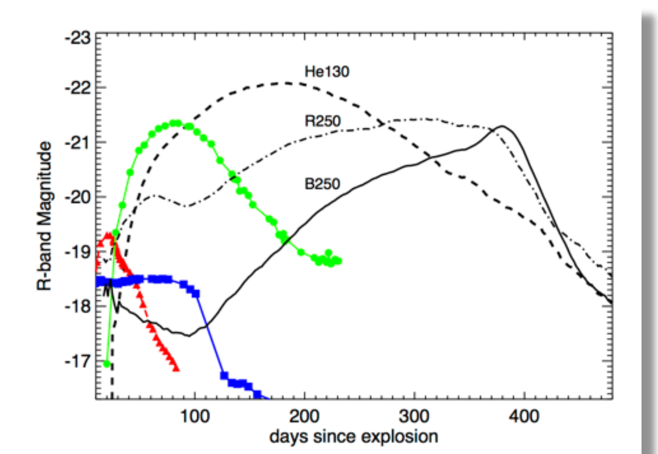
Supermassive stars spur stellar explosions



Astronomers have recently discovered a new class of brilliant, but rare ultra-luminous stellar explosions, some 100 times brighter than typical core collapse supernovae. The origin of these phenomenal displays is unclear, but they are likely related to the most massive stars to have formed in the Universe.

In a recent study, Kasen, Woosley, and Heger (Astrophysical Journal **734**, 102 (2011)) simulated the explosions of stars 150 to 250 times as massive as the sun. Stars within this mass range fall victim to a new malady, the pair-production instability: temperatures in the stellar core become high enough to produce e^+/e^- pairs, which sap the photon pressure support and initiate collapses. The compression of the core drives runaway thermonuclear burning, which eventually reverses the collapse and ejects the entire star.

A high abundance of radioisotopes (primarily ^{56}Ni) may be produced in the explosive nucleosynthesis of pair instability supernovae. The radioactive decay powers the luminosity of these events, which the calculations show can greatly exceed the brightness of ordinary supernovae for a remarkably long time (see figure). A comparison of the model light curves and spectra to observed events suggests that the pair instability may explain some of the newly discovered ultra-luminous supernovae. The implication is that stars as big as 200 solar masses are born in the Universe, and that there unusual demise has made a distinct contribution to the origin of the heavy elements.



These simulated light curves show that pair instability supernovae (black lines) outshine ordinary core collapse supernovae (blue squares) and type 1a supernovae (red triangles). The three models correspond to the explosion of a red super giant star (R250) a blue supergiant star (B250) and a compact helium star (He130). The y-axis is a logarithmic measure of the brightness of the event as observed through a red filter.

Applied nuclear physics finds a new home

As 2011 came to a close, the NSD's new Applied Nuclear Physics (ANP) program moved into its new home in LBNL building 50C. We're using this occasion as an opportunity to introduce the ANP to the wider NSD community with a brief overview. The ANP program currently consists of 10 scientists, 3 postdocs, 3 junior researchers, 15 UC Berkeley graduates, 7 undergraduate students, and is divided into three technical areas: Semiconductor Detector Fabrication, Signals and Systems, and Sensors and Algorithms. These technical areas are mapped to applications ranging from nuclear security to nuclear and astrophysics and biomedical imaging.

In the Semiconductor Detector Fabrication lab advanced semiconductors made of Ge, Si, or CdZnTe are being fabricated and new or improved fabrication processes and readout concepts are being developed. 3D-position sensitive Ge detectors are being built for gamma-ray imaging applications in nuclear security and astrophysics. Ultra-low noise detection systems based on so-called point contact detectors, and associated low mass and low noise readouts are being developed and characterized. These techniques are used, for example, for the MAJORANA project and for the search of coherent neutrino nucleus scattering, which could provide new and efficient means to detect neutrinos.

Members of the Applied Nuclear Physics program pose by their new home in Bldg. 50C.

Under the umbrella of Signals and Systems we have demonstrated – for the first time in solid-state detectors – electron-tracking based Compton imaging promising significant improvements in the detection and imaging of gamma radiation. One highlight within the Algorithms area is the fusion of object and gamma-ray image information in 3D providing new tools for nuclear security. One goal of these efforts is to develop a "Nuclear Street View," which combines visual imaging with gamma-ray imaging, both in three dimensions. The ability to reconstruct the 3D location of gamma-ray emitters over a wide range of energies can also be used to determine the lifetime of excited states populated in fragmentation reactions as envisioned in FRIB (using GRETA or GRETINA as a gamma-ray imager) or for in-situ verification of ion-cancer therapy. These examples indicate the significant potential to leverage advances in technologies and applications.

NSD Fragments

In January, the Applied Nuclear Physics program welcomed two new postdocs, Sam Huh and Michael Quinlan.

Newsletter Notes

Please send any comments, including story suggestions to Spencer Klein at srklein@lbl.gov.

Previous issues of the newsletter are available at:
https://commons.lbl.gov/display/nsd/NSD+Newsletter